

## **NASA ATP Force Measurement Technology Capability Strategic Plan**

**Ray D. Rhew**  
**NASA Langley Research Center**  
**Hampton, Virginia 23681**  
**USA**

### **Abstract**

The Aeronautics Test Program (ATP) within the National Aeronautics and Space Administration (NASA) Aeronautics Research Mission Directorate (ARMD) initiated a strategic planning effort to re-vitalize the force measurement capability within NASA. The team responsible for developing the plan included members from three NASA Centers (Langley, Ames and Glenn) as well as members from the Air Force's Arnold Engineering and Development Center (AEDC). After visiting and discussing force measurement needs and current capabilities at each participating facility as well as selected force measurement companies, a strategic plan was developed to guide future NASA investments. This paper will provide the details of the strategic plan and include asset management, organization and technology research and development investment priorities as well as efforts to date.

### **Overview**

The Aeronautics Test Program (ATP) was created to preserve the capabilities of the largest, most versatile and comprehensive set of testing facilities in the United States of America. The ATP has identified force measurement as one of the fundamental capabilities to achieve its charter. The National Force Measurement Technology Capability (NFMTC) Project is a "capability" development activity established by the ATP to fulfill this part of its charter. This Plan describes the organization, formulation, and implementation of a National Plan to revitalize this important capability by a coordinated team approach of the NASA Research Centers (Langley Research Center, (LaRC), Ames Research Center (ARC), and Glenn research Center (GRC)) and in partnership with Arnold Engineering and Development Center (AEDC). This activity is to establish the foundation for the capability by providing resources to:

Establish a national force measurement technology capability to support aeronautics test requirements for NASA, AEDC, and the nation. The initial emphasis will be on wind tunnel strain-gage balances. Once established, this capability can be utilized by the nation for all of its force measurement testing needs.

### **Introduction**

Lack of funding and focus on research over the past several years coupled with the force measurement capability being decentralized and distributed across the NASA research

centers has resulted in significant and serious erosion of: (1) NASA's working knowledge; (2) capability and infrastructure to produce and calibrate force measurement systems; and (3) the quantity of high quality, full capability force measurement systems available for use in aeronautics testing.

Simultaneously and at proportional rates the capability of industry to design, manufacture and calibrate these test instruments is eroding, due primarily to a lack of investment by the NASA aeronautics community. Technical expertise in this technology area is a core-competence in aeronautics testing; it is highly specialized, experience based and represents a niche market for only a few small precision instrument shops in the United States.

The workload at the individual research centers is not sufficient to maintain critical skills in this area. Without intervention the following will occur: (1) NASA's capability to produce, calibrate, repair and utilize these instruments in novel test arrangements will disappear altogether; (2) the number of useable balances in NASA's inventory will be significantly reduced which will severely impact NASA's ability to meet its future wind tunnel testing requirements thus impacting all the NASA mission directorates through increased schedules, costs and reduced data quality; and (3) the risks of catastrophic failure of in-service strain gage balances will increase until a catastrophic event occurs. This project has been formulated to address the erosion of this critical measurement technology of the aeronautics community. Strategic investments in infrastructure, technology development, and personnel will be utilized to maintain this critical capability for the nation.

## **Objectives**

The project goal is to establish a national force measurement technology capability to support aeronautics test requirements for NASA, AEDC, and the nation. The initial emphasis will be on wind tunnel strain-gage balances. The approach to achieving this goal is to increase critical skilled knowledge, advance technology in existing and new balances and related systems as well as demonstrate integrated systems performance using these technologies.

The capabilities and systems to be developed by the project are summarized below. This list does not include all areas. However, it represents those activities within the project since it is capabilities based activity.

- Force measurement design, strain-gaging, calibration and fabrication
- Materials, sensors, stress analyses, fracture mechanics and fatigue analyses
- Balances, calibration systems, inspection techniques
- Statistical engineering (Design of Experiments (DOE), Response Surface Methodology RSM), uncertainty analyses, statistical quality control
- Standards and training documents
- Trained personnel in force measurement technology

The Project objectives and respective approaches to achieve the objectives are described below:

**Objective 1:** Re-capitalize NASA's Strain-Gage Balance inventory.

Approach: - Develop a national database, balance readiness evaluation criteria and prioritized list of balances to add/modify to increase readiness for use inventory

**Objective 2:** Develop best practices guide for NASA strain gage balance technology.

Approach: Assemble best practices in all areas of balance development from each Center, AIAA, industry and academia.

**Objective 3:** Improve Balance Calibration Capability.

Approach: Assess current techniques and provide recommended improvements and practices through quantitative analyses.

**Objective 4:** Establish and maintain staffing to sustain capability.

Approach: Establish technical staff needed for the organization and develop training plans for each technical discipline.

**Objective 5:** Reduce contract task "turn-on" time.

Approach: Coordinate contract administration and streamline process to access all major balance vendors.

**Objective 6:** Increase research and development investment.

Approach: Develop coordinated research and development plan.

**Objective 7:** Collaborate with AEDC on force measurement activities.

Approach: Develop a Memorandum of Agreement (MOA) to coordinate all activities within this implementation plan with AEDC through either concurrence or shared responsibilities.

**Objective 8:** Collaborate with Industry and Academia on force measurement activities.

Approach: Develop activities to collaborate with industry and academia.

**Objective 9:** Be recognized as the force measurement consultants for NASA.

Approach: Develop informational brochure and contact lists within the NASA force measurement user community.

**Objective 10:** Establish a business management strategy

Approach: Develop a business management strategy to sustain the capability.

## **Organization**

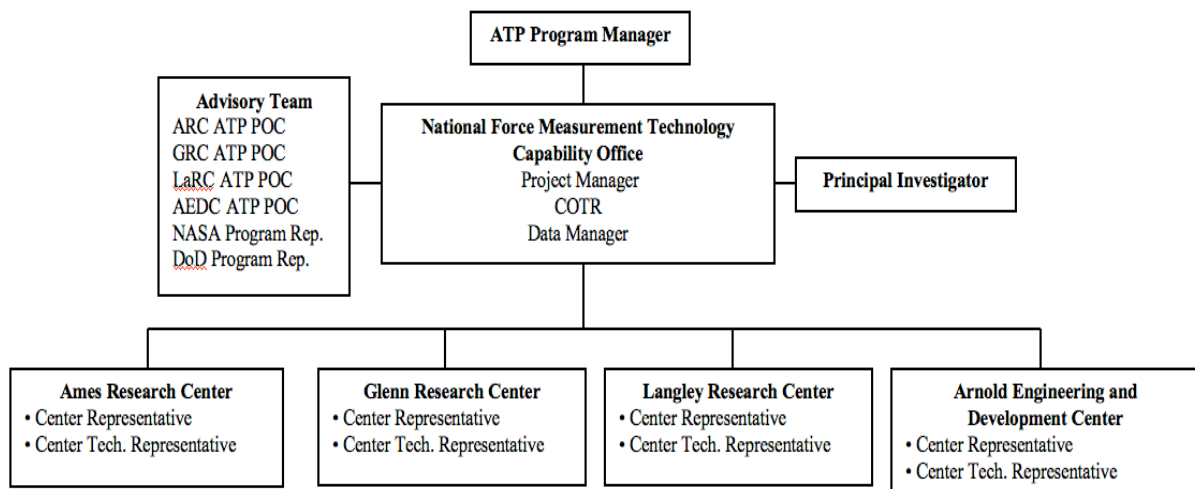
The Project is organized as shown in Figure 1. Project implementation includes NASA Ames Research Center, NASA Glenn Research Center, NASA Langley Research Center and Arnold Engineering and Development Center. The involvement of each center is shown in the organization chart (figure 1) and in table 1. Problem solving will be accomplished through the Project Team with help from the Advisory Team as needed.

6th International Symposium on Strain Gauge Balances  
May 5-8, 2008  
DNW, The Netherlands

|                                  |  |
|----------------------------------|--|
| Program Manager                  | Provide project funding and ensure requirements integrate within the overall program objectives/requirements   |
| Project Manager                  | Manage the project within the schedule, resources and meet requirements; communicate with program and center management according to the communication outlines in this plan               |
| Principal Investigator           | Provide technical direction and assessment for the project activities.   |
| Center Representatives           | Formulate research and development plans.<br>Participate in developing the implementation plan, requirements, schedule, communicating with their respective center's wind tunnel community |
| Center Technical Representatives | Provide technical support for their respective center; implement standards and provide training as needed  |

**Table 1. Role and Responsibilities**

An Advisory Team comprised of the Center ATP Program Manager, the ATP Points-of-Contact (POC) and key representatives from NASA and Department of Defense (DoD) Programs will provide input to the NFMTC Office on its planning and implementation plans from a customer perspective. This input is advisory only and not mandated to the office.



**Figure 1. NFMTC Project Organization**

## Implementation

A phased implementation approach will be utilized. Each phase and the estimated timeframe are described table 2. The emphasis is on centralizing activities that are longer term, such as new balance development, contract administration and technology development and ensure local activities such as troubleshooting, repair and urgent calibrations are handled locally to be able to respond to rapidly changing testing schedules.

6th International Symposium on Strain Gauge Balances  
May 5-8, 2008  
DNW, The Netherlands

| Phase | Major Activities  | Timeframe |
|-------|---|-----------|
| I     | Establish: Organization, Integrated Master Schedule, Requirements, Balance Inventory, Magnitude of Local service support requirements, Logistics Plan, Acquisition Management Plan        | 9 months  |
| II    | Establish: Memorandum of Agreement with AEDC, Centralize Administration of Contracts (including funding processes); Technology Development Plan, Standards Plan, Training/Succession Plan | 9 months  |
| III   | Establish: Continuous operations plan   | 6 months  |

**Table 2. Project Phases**

At the completion of Phase III the Capability will be in-place and executing a continuous operations plan. The selected plans will be reviewed and updated yearly to ensure any technology and/or NASA and AEDC mission's changes have been incorporated.

The Summary Project Work Breakdown Structure (WBS) is:

- 1.0 Project Management
- 2.0 Systems Engineering & Technical Insight
- 3.0 Development
- 4.0 Maintenance and Continuous Improvement
  - 4.1 Ames Research Center
  - 4.2 Arnold Engineering and Development Center
  - 4.3 Glenn Research Center
  - 4.4 Langley Research Center

## **Status**

The project official start date is October 1, 2008 and has been approved by the ATP Deputy Director. However, due to the momentum gained through the planning activity, and funding provided by the ATP Office, selected tasks have been initiated. Table 3 is a list of the tasks. These tasks are also designated with either infrastructure or development categories to indicate the primary role of the investment. Infrastructure is related to daily operations and development is related to introducing an improved or new capability.

6th International Symposium on Strain Gauge Balances  
May 5-8, 2008  
DNW, The Netherlands

| Item   | Category                       | Description   |
|--|--------------------------------|---|
| Weight Basket  | Infrastructure                 | Design and develop new generation weight basket for manual loadings   |
| Primary Standards Calibrated                         | Infrastructure                 | Calibrate the primary mass standards at the National Institute of Standards and Technology (NIST) according to NIST recommendations |
| Weight certification                                 | Infrastructure                 | Update balance calibration weight certifications. Also, update inventory control measures and recall system.                        |
| BALFIT   | Infrastructure and Development | Continue development of BALFIT software tool and evaluate.  |
| HiCAP Balance Evaluation                             | Development                    | Evaluate new Triumph balance for capability, accuracy, temperature compensation and stiffness.                                      |
| AEDC Collaboration                                   | Infrastructure and Development | Collaborate with AEDC on selected projects.   |
| GRC Load Cart  | Infrastructure                 | Develop a load cart for applying check loads to balances in the GRC 10x10 or 8x6 wind tunnels.                                      |
| Gage and Calibrate NTF Balances                      | Infrastructure                 | Gage and calibrate selected National Transonic Facility (NTF) balances.   |
| Balance Storage Cabinets                             | Infrastructure                 | Updated lockable storage cabinets for all balances at LaRC  |
| Balance Analysis Software                            | Infrastructure                 | Update the balance calibration analysis software used at LaRC.  |
| Calibration DAS computers and SW upgrade             | Infrastructure                 | Procure new DAS computers and upgrade SW for newest versions.   |
| Update Finite Element Analysis for selected Balances | Infrastructure                 | Perform finite element analysis (FEA) on selected balances to update operational capabilities.                                      |
| Temperature Compensation Study for Non-Cryo Balances | Development                    | Perform temperature compensation studies on Unitary balances. Utilizing cryogenic balance developed techniques.                     |
| New Bearings for Single Vector System                | Infrastructure                 | Procure and install new bearings for the Single Vector Balance Calibration System.  |
| Calibration System Study                             | Development                    | Perform calibrations on selected systems to evaluate capabilities   |
| Balance Database                                     | Infrastructure                 | Update and improve the balance database with additional search capabilities   |
| LaRC Balance Calibration Laboratory                  | Infrastructure                 | Relocate and upgrade the LaRC balance calibration laboratory.   |

**Table 3. Initial Task List**

## **Summary**

The Aeronautics Test Program (ATP) within the NASA Aeronautics Research Mission Directorate (ARMD) sponsored the development of a strategic plan to re-vitalize the force measurement capability within NASA. This paper provides the details of the strategic plan and include asset management, organization and technology research and development investment priorities as well as efforts to date. With the ATP investment, force measurement technology will provide the capability and quality required for the aeronautics community.

## **Acknowledgements**

The author would like to acknowledge and thank the major contributors to this plan.

Tim Marshall Deputy Director of the NASA Aeronautics Test Program; Jon Bader, NASA Ames Research Center Representative; Mark Woike, NASA Glenn Research Center Representative; Marc Skelley, Arnold Engineering and Development Center Representative.